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DEPARTMENT OF COMMERCE

UNITED STATES BUREAU OF MINES
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FELDSPAR GEMS

(AMAZON STONE, MOONSTONE, SUNSTONE, ETC.)

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I. AITKENS

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FELDSPAR GEMS [1]
(Amazon stone, Moonstone, Sunstone, et cetera)

By I. Aitkens [2]

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INTRODUCTION

The group of gems included under the general name "feldspar" occupies only a minor place in jewelry. Feldspars, with the possible exception of quartz, are the most important of rock-forming minerals, but most occurrences are of quite ordinary varieties, without striking color and unattractive. Few specimens are suitable for use as gem stones, but occasional crystals that exhibit unusual brilliance or play of color are cut into various shapes for personal adornment or for architectural decoration. The best known of the feldspar gems, and probably the most important in point of production, is the moonstone. Amazon stones, labradorite, sunstone, and a number of less common varieties have been produced in various parts of the world.

The present paper discusses only the gem varieties of feldspar. Data as to commercial grades are summarized in another publication[3] of the Bureau of Mines.

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[1] The Bureau of Mines will welcome reprinting of this article, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6533."

[2] Rare metals and nonmetals division, U. S. Bureau of Mines.

DESCRIPTION AND PROPERTIES

The feldspar group is a family of closely related minerals, all of which are composed of compounds of silica and alumina with varying amounts of soda, potash, or lime. The more important members of the feldspar group are orthoclase, microcline, albite, oligoclase, labradorite, and anorthite. The formulas for the principal varieties of feldspar are as follows:

Orthoclase and microcline	Potassium-aluminum silicate	$KAlSi_3O_8$
Albite	Sodium-aluminum silicate	$NaAlSi_3O_8$
Oligoclase	Aluminum-calcium and sodium silicate	$3NaAlSi_3O_8 \cdot 1CaAl_2Si_2O_8$
Labradorite	do	$1NaAlSi_3O_8 \cdot 3CaAl_2Si_2O_8$
Anorthite	Aluminum and calcium silicate	$CaAl_2Si_2O_8$

In crystallization, orthoclase is monoclinic, while the other feldspars are triclinic. Twinning is very common, and all varieties show cleavages in two directions. The hardness is about 6 and the specific gravity ranges from 2.5 to 2.8.

Feldspars are colorless, white, pale yellow, green, or reddish. Most of them, however, are without striking color or optical effects. They have a vitreous to pearly luster and are transparent to opaque. Although the mean index of refraction varies from 1.52 to 1.58, the double refraction is low, ranging from 0.005 to 0.012. Dispersion in the feldspars is also low, albite being 0.012. All the feldspars are biaxial; albite and labradorite are optically positive but the other varieties are negative.

Moonstone

The gem varieties of orthoclase are transparent and colorless and are called adularia, or moonstone when opalescent. However, there are moonstone varieties of albite and oligoclase also.

Amazon stone

The bright green variety of microcline is called amazon stone or amazonite. This varies from a light verdigris-green to a deep blue green and finds wide application on account of its pleasing color, which is very similar to jade.

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[3] Bowles, Oliver, and Lee, C. V., Feldspar: Inf. Circ. 6381, Bureau of Mines, October, 1930, 21 pp.

Sunstone or Aventurine

Sunstone, or aventurine oligoclase is reddish, with bright yellow or red reflections. These reflections are caused by iron oxide and foreign inclusions which give the mineral a golden shimmer and sparkle.

List of Varieties

Besides the more important members already given, the feldspar group of gems is divided into many classes under the different classifications and divers names have been given them. The following alphabetical list gives the gem and mineral names of the feldspar group:

Gem name	Common name or description
Adularia	Orthoclase (feldspar).
Albite	Silicate of aluminum and soda (feldspar).
Albite moonstone	Iridescent albite.
Amazone stone	Green microcline (feldspar), silicate of aluminum and potassium.
Andesine	Silicate of aluminum, sodium, and calcium (feldspar).
Adventurine feldspar	Sunstone.
Bemiscite	Salmon-colored feldspar from Bemis, Maine.
Bull's eye	Labradorite with a dusky sheen.
Cassinite	Pearly, bluish green aventurine feldspar from Delaware County, Pa.
Ceylon opal	Moonstone.
Changeant	Labradorite.
Chesterlite	Microcline feldspar from Chester County, Pa.
Delawarite	Aventurine feldspar from Delaware County, Pa.
Feldspar sunstone	Sunstone.
Fish-eye	Moonstone.
Graphic-granite	Pegmatite composed of quartz and feldspar so arranged as to simulate writing.
Heliolite	Sunstone (feldspar).
Labrador feldspar	Labradorite.
Labrador spar	Labradorite.
Labrador stone	Labradorite.
Labradorite	Feldspar, silicate of aluminum, sodium and calcium.
Leelite	Deep flesh-red orthoclase (feldspar) having a waxy luster.
Lennilite	Greenish feldspar from Lenni Mills, Delaware County, Pa.
Microcline	Potash feldspar in triclinic crystals, silicate of aluminum and potassium.
Moonstone	Feldspar (usually oligoclase or the adularia variety of orthoclase) showing a pearly opalescence; also commonly but erroneously applied to some white or gray chalcedony and to satin spar (gypsum).
Oeil de boeuf	Labradorite (feldspar).
Oligoclase	Feldspar, silicate of aluminum sodium, and potassium.

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Gem name	Common name or description
Opaline feldspar	Labradorite.
Orthoclase	Potash feldspar in monoclinic crystals, silicate of aluminum and potassium.
Orthose	Moonstone (feldspar).
Ox-eye	Labradorite (feldspar).
Peristerite	Iridescent albite (feldspar).
Perthite	Potash feldspar (orthoclase or microcline) with laminae of soda feldspar (albite).
Sunstone	Feldspar (usually oligoclase or labradorite) containing inclusions of minute scales of iron oxide.
Variolite	Dark green orthoclase (feldspar) containing lighter-colored globular particles.
Water opal	Moonstone (feldspar).
Wolf's eye	Moonstone (feldspar).

USES

Besides being used in jewelry, feldspars are cut into various shapes for personal adornment and for architectural decorations. Ordinary feldspar is used chiefly in the ceramic and glass industries, and to a minor extent as an abrasive in scouring preparations, but is also employed for a variety of other purposes.

IDENTIFICATION

The feldspars are readily distinguished by their optical properties, moderate hardness, pronounced cleavage, and peculiar color phenomena. Orthoclase and microcline are only distinguished from each other by careful examination. Both are difficultly fusible and insoluble in acids. They are distinguished from the other feldspars by their right-angle cleavage and the lack of striations on the best cleavage surface.

The plagioclase or soda-lime feldspars (albite-anorthite series) are a trifle more fusible and not quite so hard as the potash feldspars, but these varieties are so similar to one another that they can often be distinguished only by a chemical analysis or a thorough optical examination.

SUBSTITUTES

With the exception of microcline, anorthoclase, and hyalophane, all the feldspars have been synthetically prepared. Those requiring the use of fluxes for their preparation are orthoclase, celsian, and albite. Anorthite melts sharply at 1,550° C. However, there is little commercial advantage in manufacturing feldspar gems on account of their relatively low value and comparatively small use as semiprecious stones.

HISTORY

The name "feldspar" was used by Wallerins in his mineralogy in the Swedish

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form feltspat, which means field spar. It was subsequently written "felspar" when it was erroneously assumed that the word was derived from fels, meaning a rock. Feldspar is derived from the German word feld, meaning a field, but in German the old name is preserved as "feldspat." The preferred American spelling is "feldspar," but in England "felspar" is in general use. Both spellings, however, are commonly seen.

Adularia or moonstone

Gem varieties of orthoclase when opalescent are called moonstone, and adularia when transparent or colorless. The finest stones at one time came from the St. Gothard district in Switzerland and were known as adularia, from the neighboring Adular Mountains.

Amazon stone

Amazon stone, the opaque, green feldspar obtains its name from the Amazon River, where, however, none has ever been found. Beautiful green stones were found on the banks of the Amazon and these may have been confused with the mineral of the feldspar group or with jade or a similar mineral.

Labradorite

Originally the finest specimens of labradorite came from the Isle of St. Paul off the coast of Labrador, where they were first discovered in 1770. This stone gets its name from Labrador, which country still is its most important locality.

MODE OF OCCURRENCE

Feldspar occurs as an accessory constituent of all types of rocks; igneous, sedimentary, and metamorphic. Its most common occurrences are in granites, syenites, porphyries, certain sandstones and conglomerates, and in gneisses. Good crystals occur chiefly in pegmatite veins associated usually with quartz, muscovite, etc. Such veins are to be found in regions where granitic rocks abound.

MINING METHODS

Practically all the mining done in the United States for gem feldspar has consisted of pits, small open cuts, and occasional tunnels. The various workings for amazon stone and other feldspar minerals cover considerable ground where there are pits every few feet in most instances, but none of them are very deep. In fact, most of the workings are less than 12 feet deep.

DOMESTIC PRODUCTION

The production of feldspar gems in the United States has always been exceedingly small. Although the mineral itself is widely distributed through many States, feldspar of gem quality has not been mined to a considerable extent, because only exceptionally fine stones are worth more than the cost of cutting. The following table gives the value of feldspar gems produced in the United States from 1900 to 1921, when the United States Geological Survey discontinued the canvass of producers:

Table 1. - Value of feldspar gems produced in the United States 1900-1921 1/

Year	Value	Year	Value	Year	Value
1900	$ 270	1908	$2,850	1915	$ 368
1901	200	1909	2,700	1916	305
1902	500	1910	2,510	1917	(2)
1903	400	1911	175	1918	(2)
1904	500	1912	1,310	1919	(2)
1905	1,000	1913	1,285	1920	520
1906	100	1914	449	1921	155
1907	1,110				

1/ Compiled from annual chapters of Mineral Resources of the United States, Part II.

2/ Less than three producers; figures not published separately.

DEPOSITS IN THE UNITED STATES

Although some gem orthoclase and oligoclase have been produced in the United States, and labradorite, sunstone, and moonstone have been found in certain localities, amazon stones seem to be more widely distributed and to have been produced to a greater extent than any of the feldspar gems.

Amazon Stone

California. - A number of specimens of amazon stone were collected in the deserts of California somewhere between Barstow and Lone Pine. This material consisted of fragments and crystals which ranged from small sizes to an inch in thickness. A few of the specimens sent to the United States Geological Survey were especially good shades of bluish green and greenish blue, with fairly smooth, fine texture. This locality should prove of value if larger crystals of the same good color can be obtained in quantity. However, this region has not been very extensively exploited up to the present time.

Colorado. - The Pikes Peak region has long been famous as a source of beautiful crystals of amazon stone and associated smoky and clear quartz. There are two localities where amazon stone is found, one to the east of Pikes Peak, in the Crystal Park region near Manitou Springs, and the other about 18 miles northwest of Pikes Peak, and about 4 miles north of Florissant. Some of the amazon stone is of good gem quality and has a rich green and bluish green color, while other stones are pale or badly stained with iron. These crystals of amazon stone are generally well developed, and vary in

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size from a fraction of an inch to 3 or 4 inches square; the larger pieces furnish fine cabinet specimens for mineral collections. Whitman Cross[4] and W. F. Hillebrand have described the minerals of this region.

The bulk of the feldspar used as a precious stone has been produced by Colorado, and the amazon stone leads all the others in value. George F. Kunz[5] states that an exhibit of Colorado amazon stone at the World's Fair in Philadelphia in 1876 occasioned much surprise because of its beauty.

Maine. - Amazon stone was found along the coast of Maine during 1914. This discovery was made late in the fall, so that little prospecting was possible and only about a pound of crystals was obtained. The specimens submitted to the United States Geological Survey were rather small but would cut into gems of pleasing color. If larger masses of equally good quality could be obtained this deposit would be of interest to the New England semiprecious stone trade. However, this locality has not been seriously exploited up to the present.

New York. - Prof. Freeman F. Burr, of Barnard College, New York City, submitted to the United States Geological Survey several crystals of amazon stone which he had collected from the quarry at White Plains, N. Y. This quarry was then being worked for materials to be used in the construction of Kensico dam for the New York City water supply. One crystal from this quarry, measuring 7 by 7 by 5 inches was placed in the collection of Columbia University. Some of these crystals were fairly well developed, and the best specimen submitted to the United States Geological Survey showed a bright translucent bluish green color; this stone, however, could not be cut into a pure gem on account of the markings. Professor Burr[6] describes the occurrence of amazon stone at White Plains, N. Y., and states that a few of these stones have been cut as gems but none have been regularly placed on the market.

Pennsylvania. - An occurrence of amazon stone with sunstone was reported to the United States Geological Survey about 1908, at a locality 1 mile west of Media, Delaware County, Pa. These minerals were found loose in the soil, where they were brought up from pegmatite ledges by the action of frost.

Virginia. - Fine specimens and gem minerals have been obtained from the mica mines of the Amelia Courthouse region, Virginia. A description of this locality and its minerals has been given by W. F. Fontaine,[7] who mentions evidences of work by Indians or other persons. Amazon stone abounds at these mica mines where it occurs in a coarse pegmatite associated with other varieties of feldspar.

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[4] Cross, Whitman, and Hillebrand, W. F., Minerals from Pikes Peak: Am. Jour. Sci., 3d ser., vol. 24, 1882, pp. 281-286.

[5] Kunz, G. F., Gems and precious stones of North America: New York, 1890, p. 165.

[6] Burr, F. F., Occurrence of Amazon Stone at North White Plains, New York: Sch. of Mines Quart., vol. 36, 1915, pp. 186-188.

[7] Fontaine, W. F., Notes on the Occurrence of Certain Minerals in Amelia County, Va.: Am. Jour. Sci., 3d ser., vol. 25, 1883, pp. 330-339.

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According to Doctor Foshag,[8] the color of the amazon stone of Amelia, Va., is more pleasing even than that of Colorado. He further states that although this is massive and not in large and freely developed crystals as in Colorado, it possesses a pleasing and uniform shade that is better suited for cutting into beads and other ornamental forms.

Labradorite

Oregon. - About 1908, a report of the discovery of a new deposit of labradorite in southern Oregon was made by Maynard Bixby, of Salt Lake City, Utah, who stated that this mineral would yield handsome gem material. This labradorite ranges from colorless to a dark variety, showing fine red, salmon, and green tints.

Utah. - A new find of transparent pale yellow labradorite from Millard County, Utah, was reported by Kunz.[9] At this locality it was found occurring in scoria and is of interest as a gem, although it is not of great hardness. It is almost identical with the occurrence of the Altar Mountains location of Arizona, which was the first reported instance of a transparent labradorite.

Moonstone

Virginia. - Specimens of moonstones obtained from a mica mine were received from Hewlett, Va. This variety of orthoclase feldspar occurs in pockets in veinlets of partly kaolinized feldspar in a decomposed mica gneiss formation, which pockets range from the size of an egg to that of a cocoanut. The material examined was slightly yellowish, not the pure white of good moonstone, and although it displays a certain amount of the chatoyancy of moonstone, it was not so strong as the Ceylon moonstone.

Sunstone

Arizona. - Dr. H. P. Wightman of Globe, Ariz., submitted to the United States Geological Survey specimens of andesine feldspar, some of which showed the characters of sunstone. These specimens were collected by the Apache Indians from their reservation not far from Globe, and resemble the sunstone from Modoc County, Calif. Microscopic examination showed it to be andesine wit a refractive index of 1.550. While one piece of this material was a pale yellowish color, another showed bright copper-colored reflections from inclusions along certain lines of crystallization parallel to one of the cleavages.

California. - Quite a quantity of sunstone from Modoc County, Calif., has been cut into gems, specimens of which were received by the United States Geological Survey from the Pacific Gem Co. of Los Angeles, Calif. These cut gems are very pretty and have been sold under the name of both goldstone and sunstone. This feldspar comes rather high in calcium, with many minute inclusions that reflect a bright coppery red light. In some specimens these particles are almost submicroscopic but sufficiently abundant to impart a red color. However, the body of the feldspar material is colorless and clear.

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[8] Foshag, Wm. F., Gems and Gem Minerals: Smithsonian Sci. Ser., vol. 3, pt. 2, 1929, pp. 262-267.

[9] Kunz, G. F., The production of Precious Stones for the Year 1915: Min. Ind., 1916, p. 611.

FOREIGN LOCALITIES

Amazon Stone

Amazon stone or amazonite, occurs chiefly in the Ilmen Mountains, Russia, Siberia, and Scotland. This bright variety of microcline is a very popular shade for brooches and the like, and is often cut cabochon on account of its pleasing color.

Labradorite

The foreign deposits of labradorite are found mainly in Finland, Russia, and on the coast of Labrador. Labrador is the most important locality.

Moonstone

Ceylon is the principal source of moonstone. In fact, practically all the moonstones on the market now come from Ceylon, although at one time the finest came from the St. Gothard district in Switzerland. In recent years extensive deposits of superb stones with rich reflections have been obtained and sent to the gem markets all over the world, with the result that Ceylon is now noted as a producer of the finest moonstones obtainable.

Sunstones

Sunstones of very excellent quality are produced in many parts of the world. According to Doctor Foshag,[10] rarity gave sunstone considerable popularity at one time, but it lost that asset when a number of localities yielding abundant quantities appeared, especially at Tvedestrand in Norway.

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[10] Foshag, Wm. F., Work cited, pp. 264-265.

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